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(56) Documents cited
GB 1533859 A GB 1459814 A EP 0365406 A1
WO 91/04508 A2 US 5034732 A US 4997263 A
US 3776016 A

(58) Field of search
UK CL (Edition L) G2J JHU
INT CL[6] G02B

(54) Helmet-mounted display

(57) A helmet-mounted display eg for "virtual reality" has two back-lit liquid crystal displays 30 and 30' and collimating lenses 23 and 23' mounted towards the rear of the head which produce collimated beams of light. A pair of reflectors 24 and 24' close to the displays reflect the light beams to another pair of reflectors 25 and 25' located at the front of the helmet. These reflectors reflect the light down directly onto reflective areas 26 and 26' which may be semi-transparent on the helmet visor 27 which is angled to direct an image of the displays into the line-of-sight of the user. Single displays and optics may be used for mono-vision.

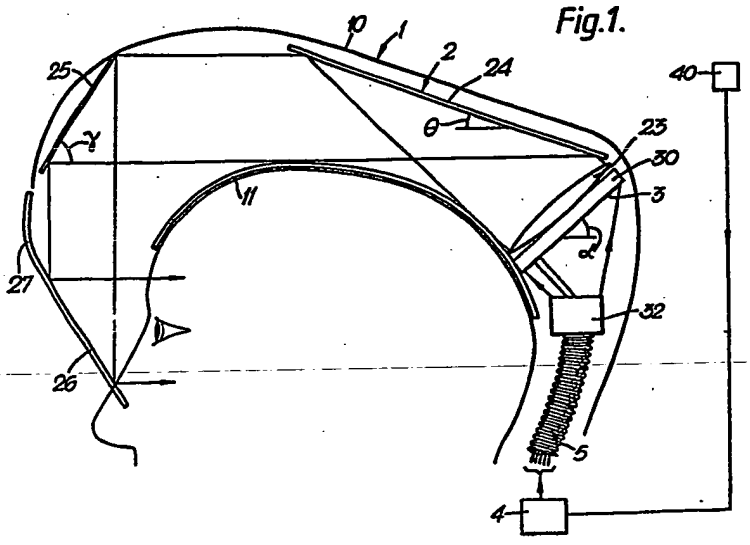

Fig.1.

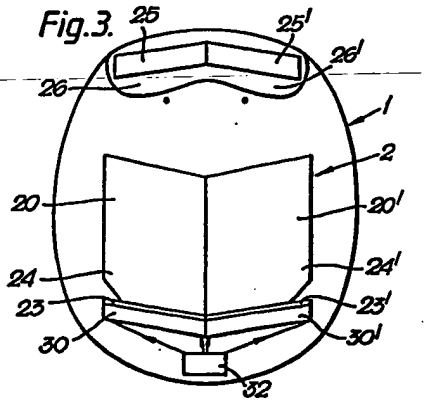

Fig.3.

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Fig.1.

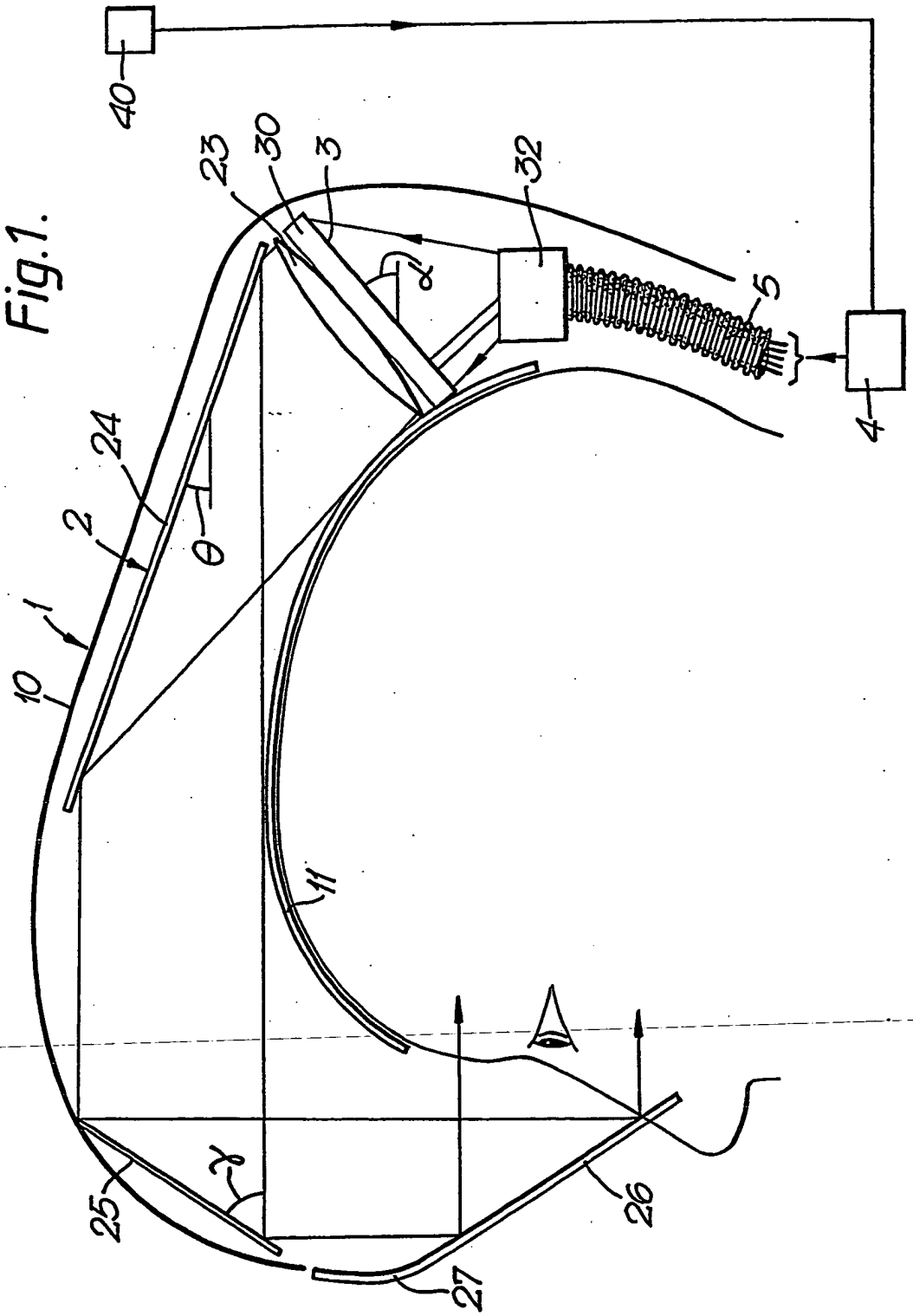


Fig.2.

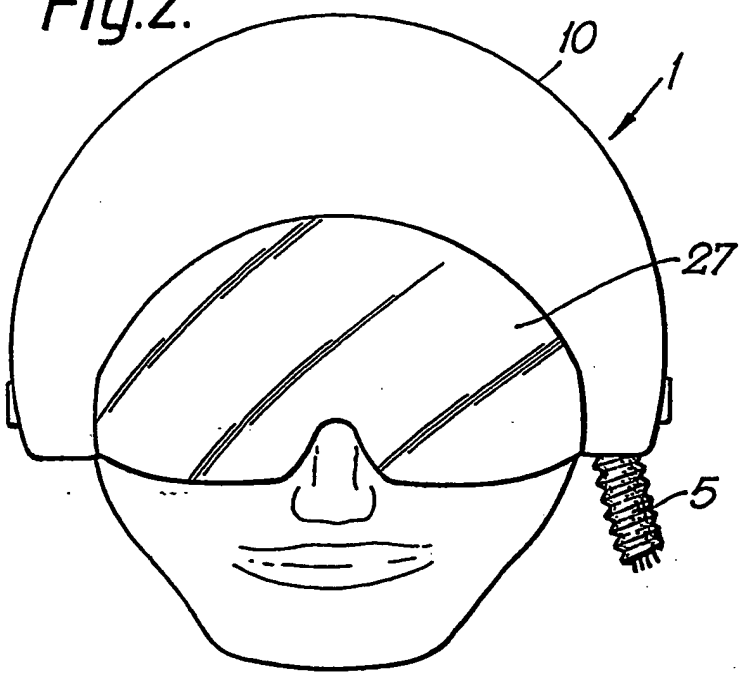
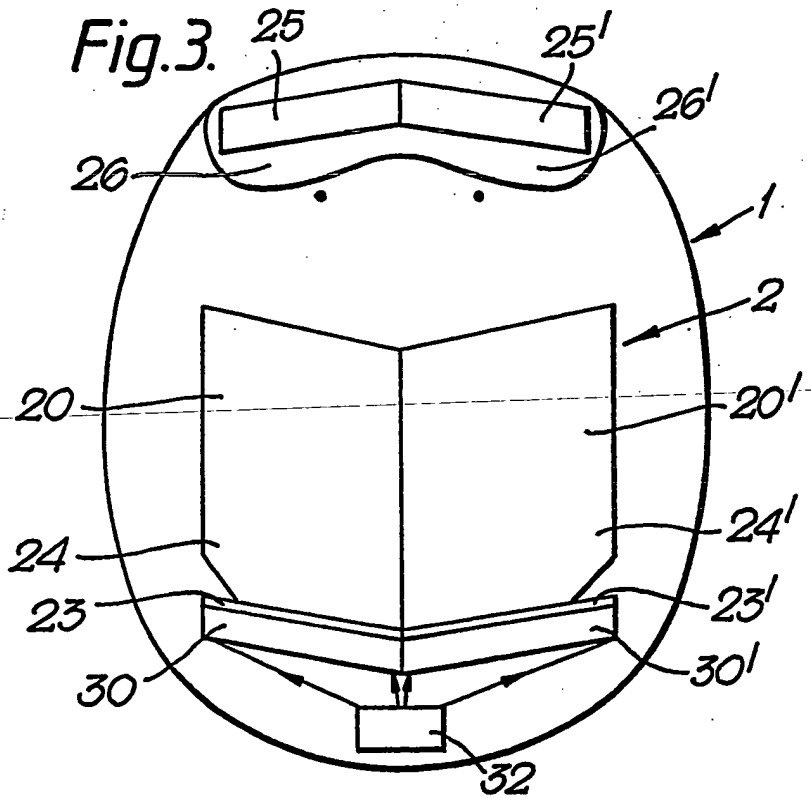


Fig.3.



HEAD-MOUNTED DISPLAY APPARATUS

This invention relates to head-mounted display apparatus.

Head-mounted displays have been used to present an image to the wearer in his line-of-sight. Such apparatus may take the form of a pair of goggles containing the display. Alternatively, the display may, for example, be mounted behind or to one side of the wearer's head and an image directed in front of the eyes by a system of lenses.

Previous apparatus have disadvantages. They tend to be bulky and heavy, because of the optical system used to direct light from the display to the eyes. They also tend to be expensive. Where the apparatus is to be worn for long periods, such as by aircraft pilots, it is a great advantage for the weight of the apparatus to be minimized. Recently, head-mounted displays have been proposed for virtual world applications where the wearer is presented with a computer-generated image of an environment within which he may move. It would be a considerable advantage for the cost of head-mounted display apparatus to be reduced in order to be able to exploit fully the potential market for virtual world applications.

According to one aspect of the present invention there is provided head-mounted display apparatus for presenting an image in the line-of-sight of the wearer of the apparatus, the display including a light-emitting display unit, means for collimating light emitted by the unit into a beam directed forwardly across the top of the head of the wearer onto a first reflector inclined from the vertical, the first reflector being arranged to direct the beam of light downwardly onto a second reflector mounted in the line-of-sight of the wearer, and wherein the second reflector is arranged to reflect the beam of radiation into the line-of-sight of the wearer.

The apparatus preferably includes an additional reflector mounted adjacent the collimating means, the additional collimating means being arranged to reflect the collimated beam of light generally horizontally to the first reflector. The second reflector is preferably semi-transparent so that the wearer can view the external scene through the second reflector with an image from the display superimposed on the external scene. The apparatus may be mounted in a helmet, the second reflector being provided by a visor of the helmet. The apparatus preferably includes a pair of display units and a pair of second reflectors, each display unit being arranged to provide an image for viewing by respective eyes of the wearer. The display unit may include a liquid crystal display which may be a back-lit liquid crystal display.

Helmet-mounted display apparatus in accordance with the present invention, will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional side elevation of the apparatus;

Figure 2 is a front elevation view of the apparatus; and

Figure 3 is a cut away plan view of the apparatus.

The display apparatus comprises a helmet 1 containing an optical system 2 and a display unit 3 which is connected to a processor 4 via a flexible cable 5.

The helmet 1 has an outer shell 10 of a protective, light-proof material which is supported on the wearer's head by conventional padded, shock-absorbing inner liner 11 which spaces the shell above the head of the wearer.

The display unit 3 has two multi-colour flat displays 30 and 31 which may take the form of back-lit liquid crystal displays such as of the kind described in GB 2254724. The displays 30 and 30' are mounted side-by-side at the rear of the helmet 1 and are inclined from the horizontal at an angle α of about 45 degrees. The displays 30 and 30' are driven by signals from a drive electronics unit 32 which is also mounted within the helmet and to which the cable 5 is connected. Both displays 30 and 30' are driven by the processor 4 to generate different display representations for the left and right eye respectively.

The optical system 2 is divided into two parallel channels 20 and 20' (Figure 3) to provide an optical path between each display 30 and 30' and the respective eye. The left-hand channel 20 comprises a collimator 23 formed by an achromatic pair of lenses which is located directly front of the display 30. This produces a parallel beam of light directed at an angle of 45 degrees to the horizontal, forwardly and upwardly over the wearer's head. The beam of light is incident on a first mirror 24 which is a plane mirror of rectangular shape inclined at an angle θ of about 22 degrees to the horizontal so that the beam of light is reflected forwardly over the head of the wearer generally horizontally. The optical system 2 also includes a second plane mirror 25 mounted at the front, top of the helmet 1 and inclined at an angle γ of about 45 degrees to the horizontal. The action of this mirror 25 is, therefore, to direct the beam of light vertically downwards. The final component in the optical system 2 is a third reflector 26 provided by a part of a visor 27 which is semi-transparent. The visor 27 is supported by the helmet 1 at opposite sides so that it can be

swung up out of the line-of-sight, or down into the position shown in the drawings. The visor 27 need not be plane over its entire surface, providing that it has flat regions which are located directly in front of the eyes of the wearer and inclined at 45 degrees from the horizontal when the visor is in the down position. The inclination of the visor 27 is such that, when it is down, its lower edge is closer to the wearer's head than the upper edge. The visor 27 is located directly beneath the second mirror 25 so that light from the second mirror is incident directly on the visor without the interposition of any other optical element. The inclination of the visor 27 is such that the beam of light is reflected horizontal, rearwardly into the line-of-sight of the left eye of the wearer. The wearer will, therefore, see an image at infinity of the display representation on the display 30.

The right-hand channel 20' of the optical system 2 contains the same elements as the left-hand channel 20 and is arranged to direct an image of the right-hand display 30' into the line-of-sight of the right eye. In this way, a stereoscopic, or 3-D, display representation can be presented to the user.

The semi-transparent nature of the visor 27 enables the wearer to view the external scene through the visor, the display representation being superimposed on this. alternatively, such as for virtual world applications, the visor need not be transparent, the wearer only being able to see the display representation and not the external scene.

The image presented to the wearer may be changed, in a known way, according to the orientation of the helmet so that, for example, when the wearer looks up, the display provides a suitable representation of the sky, or of an image to be superimposed on the sky. In this respect, a helmet position sensor 40 may supply signals to the processor 4 in response to the helmet orientation so as to control the generation of appropriate display representations.

The mirrors 24, 24' 25, 25', 26' and 26' are conventional metallized glass plates but could be provided by other forms of reflector. In particular, the reflective areas 26 and 26' on the visor 27 could be formed by holographic elements which are selected to have an angle of reflection that is smaller than the angle of incidence so that the visor can be inclined closer to the vertical. This has the advantages that it enables the field of view in elevation to be increased and it may reduce the risk of the visor causing injury to the wearer in an accident.

The apparatus need not have two separate displays if a stereoscopic presentation is not required. Instead, a single display could provide an image in the line-of- sight of both eyes. The use of a flat panel display has advantages of robustness and low weight but alternative displays, such as a CRT could be used. Instead of containing the apparatus in a helmet, it would be mounted on a framework supported by a head band.

The arrangement of the present invention has the advantages that it enables a relatively wide field of view to be achieved with a low number of optical components. It can have a low weight, be robust and its simplicity enables it to be made at relatively low cost.

CLAIMS

1. Head-mounted display apparatus for presenting an image in the line-of-sight of the wearer of the apparatus, wherein the display includes a light-emitting display unit, means for collimating light emitted by the unit into a beam directed forwardly across the top of the head of the wearer onto a first reflector inclined from the vertical, wherein the first reflector is arranged to direct the beam of light downwardly onto a second reflector mounted in the line-of-sight of the wearer, and wherein the second reflector is arranged to reflect the beam of radiation into the line-of-sight of the wearer.

2. Head-mounted display apparatus according to Claim 1, including an additional reflector mounted adjacent the collimating means, and wherein the additional reflector is arranged to reflect the collimated beam of light generally horizontally to the first reflector.

3. Head-mounted display apparatus, wherein the second reflector is semi-transparent so that the wearer can view the external scene through the second reflector with an image from the display superimposed on the external scene.

4. Head-mounted display apparatus according to any one of the preceding claims, wherein the apparatus is mounted in a helmet, and wherein the second reflector is provided by a visor of the helmet.

5. Head-mounted display apparatus according to any one of the preceding claims, including a pair of display units and a pair of second reflectors, and wherein each display unit is arranged to provide an image for viewing by respective eyes of the wearer.

6. Head-mounted display apparatus according to any one of the preceding claims, wherein the or each display unit includes a liquid crystal display.

7. Head-mounted display apparatus according to Claim 6, wherein the or each display unit includes a back-lit liquid crystal display.

8. Head-mounted display apparatus substantially as hereinbefore described with reference to the accompanying drawings.

9. Any novel feature or combiination of features as hereinbefore described.

Pat nts Act 1977
F··aminer's report to the Comptroller under
Section 17 (Th Search Report)

Application number

GB 9303413.0

Relevant T chnical fi lds

(i) UK Cl (Edition L) G2J (JHU)

(ii) Int Cl (Edition 5) G02B

Search Examiner

R E HARDY

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

1 APRIL 1993

Documents considered relevant following a search in respect of claims 1-8

Category (see over)	Identity of document and relevant passages		Relevant to claim(s)
X	GB 1533859 A	(ELLIOTT BROS) Figure 3, prism 37 and visor 29	Claim 1 at least
X	GB 1459814 A	(HONEYWELL) Figure 1, mirrors 70, 76, 80	Claim 1 at least
X	EP 0365406 A1	(THOMSON-CSF) Figure 2	Claim 1 at least
X	WO 91/04508 A2	(GEC) The Figures	Claim 1 at least
X	US 5034732 A	(IINO) Figure 9	Claim 1 at least
X	US 4997263 A	(COHEN ET AL) Figure 4, mirrors 40, 44	Claim 1 at least
X	US 3778016 A	(ROSSIRE) The Figures, mirrors 20, 22	Claim 1 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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